1. INTRODUCTION

Digitalization of information and communication is increasing very fast but uses of paper documents have still maintained their importance [11]. Authenticity of document is a major question in forensic document examination. Document examiner examines disputed documents to find out genuineness and non-genuineness of a document and also to confirm authorship. A document is generally composed of paper, handwriting, signature, printing, typewriting and seal etc. Writing papers are of various types- Bond paper, Gloss paper, uncoated paper, matte paper, photo paper etc. Likewise, handwriting inks are composed of oils or glycols and dyes and liquid ink pens which contain inks composed of aqueous solution of solvents and dyes or pigments or both [12]. If any document contains signature, it plays a vital role as it establishes the document as authentic and genuine by its presence. Since documents have importance in personal and professional conducts, chances of forgeries in content of documents completely or partially is very common. With development in document copying technologies like scanners, different types of printers and photocopiers, it has also become common to keep reproduced copies of important documents for safety purpose. In the situations when original copy of a document is either lost, damaged or not available due to some reasons, reproduced copy of the same may be used in leu of original one. In majority of cases the reproduced copies are kept certified by the competent authorities. In both situations where copy of a document is certified or uncertified, a signature may be challenged for its genuineness or non-genuineness. It may also be possible that a perpetrator prepares a fraudulent document and may use reproduced copy of the same with the assumption that the reproduced copy is hard to detect. Here it may be claimed by the perpetrator that the original one was lost or damaged.

In every situation when a signature is challenged for its authenticity, comparison of admitted signatures with questioned signatures present in reproduced document becomes necessary. It is well known fact that all signature characteristics of originals can never be exactly reproduced via any document reproduction processes viz. scanner- printers or photocopiers. Furthermore, each reproduction

process has different technologies like printing process have inkjet, laser and dot matrix, similarly photocopying process have analog and digital technologies.

Thus, it becomes significant to study the effect of different reproduction technologies on decipherment of signature characteristics in reproduced documents. Sometimes various generations of copies from reproduced copies are also prepared and used due to some reasons; here it also becomes significant to study effect of different successive generations of document reproductions on decipherment of signature characteristics. Identification of determinant signature characteristics in reproduced documents play an important role in criminal investigation. In this situation it becomes necessary to check whether sufficient signature characteristics are present in the copy or not for the purpose of examination and comparison. In the present study analysis of determinant signature characteristics in scanned and printed documents as well as in photocopied documents will be performed. Analysis of decipherment of signature characteristics in successive generations of reproduced documents will also be carried out using different physical, spectral methods of analysis.

2. REVIEW OF LITERATURE

1. Gupta, R. R. (2018) discussed about challenges faced by the question document examiners in examination of photocopied documents and reported that every photocopying machine has its own limitations which affect photocopying of any document at certain extent. Therefore, it may be difficult to interpret some characteristics like line quality, morphology of ink, ink gooping, hesitation and tremor etc. However, certain characteristics viz. formation of letter, spacing between letters and words, slant, initial and terminal strokes are still available for the examination and comparison.

2. Tarannum, A. (2018) examined three cases of disputed signatures and studied characteristics like tremor, pen lift, line quality, formation of letters, initial and terminal strokes along with superimposition technique for detection of forgery. During comparison of questioned signatures with admitted, it was observed that initial strokes, formation of letters, terminal strokes etc. in questioned signatures showed pictorial similarity with the admitted signatures. Forgery of signatures by superimposition was confirmed by this method.

3. Saroa, J. S. et al. (2016) discussed about problems of authenticity determination of documents in photocopies. Samples of photocopied documents containing typed, printed and handwritten signatures were collected. Alterations like addition, deletion and transplantation were made in typed, printed and handwritten signature portions of these documents. These samples were examined for stroke quality, extra toner deposition, discontinuity of dots, slant, size, spacing between letters and lines, alignment for detection of alterations in documents. Photocopies up to three generations were also collected to observe effect of successive generations of photocopying on these characteristics. Result showed that detection of alterations in documents can be possible considering these characteristics cumulatively. It was also observed that possibility of detection of alterations diminishes with increase in generation of photocopies.

4. Mishra, V. C. et al. (2015) examined forged signature case and considered speed, tremors, pen pause, pen lifts, initial and terminal strokes along with superimposition technique to detect companion tracing. Superimposition test showed 95% similarity. Comparison of signature characteristics showed difference

in speed, presence of tremor, unnatural pen pauses and pen lifts, concealing of joining, and initial and terminal strokes. Collective consideration of the two-way examination established forgery of the questioned signature by companion tracing.

5. Mane, M. (2014) discussed about individual characteristics of signatures pen pressure, shading, pen pause, pen lift, starting and ending strokes, hesitations, retouching, embellishments, placing, size. Different types of signature forgeries like carbon paper tracing, indented tracing, tracing paper, carbon paper tracing, transmitted image, scanned image forgeries were reported. Further explained that crude forgeries normally contain patching, slowness, hesitations in the writing which help to detect forgeries.

6. Desai, B. et al. (2013) classified signatures into formal signatures, informal signatures and careless scribble. Further it was reported that all documents presented are not necessarily genuine because in forged case forger tries his best to resemble like genuine. Characteristics of authentic and forged signatures were listed and different handwriting characteristics involved in the examination of handwriting and signatures viz. slant, movement, loops, alignment, spacing, strokes, skill, arc, pen pressure, pen pause, pen lift, hesitation were discussed for their identification.

7. Patil, P. et al. (2013) developed a biometric system for offline signature recognition. Some global features of signatures like area, height, width, ratio of height and width were used as identifying features. This software stored all these data in its data base after preprocessing and feature extraction. Identification and recognition genuine and forged signatures were possible by this model on the basis of algorithm of characteristics developed.

8. Saini, K. et al. (2008) collected samples from 20 different subjects. Copies of these signatures were produced by two volunteers by imitation and tracing methods. These genuine and copied signature samples were then photocopied by using six different photocopier machines. The signature characteristics were then examined in all the samples and concluded that examination of photocopies can be done in photocopied documents, however some characteristics like pen pause, pen lift, pen skipping and pen patching are commonly misinterpreted.

9. Dawson, G. et al. (1998) carried out a study on photocopied signatures. For this purpose, one photocopied signature along with known standard signatures was sent

to qualified document examiners of different countries. The examiners were asked to examine and compare components of line quality like tremor, hesitation mark, pen lifts, pen patching, blunt initial and terminal strokes, and abrupt changes in the direction of strokes in original samples as well as photocopies. Overall 95% of line quality characteristics were assessed accurately. This indicated that line quality can be identified in photocopies and similarity and differences in line quality can also be made between original and photocopies.

10. Totty, R. (1990) discussed about different techniques available for photocopied document analysis. Examination and comparison of paper, examination and comparison of inks (toners) and examination of defects and traces produced by photocopiers were carried out. It was further reported that with increase in the uses of photocopier machine there is increase in deterioration of its components like drum, glass surface, lid which may also affect the reproduction quality of documents.

3. **RATIONALE**

In this fast-growing digital era paper documents have still maintained their importance. Preparation of copies of a document by scanning printing or photocopying may be in both intents- genuinely and fraudulently. There may be a variety of situations where examination of signature becomes necessary for forensic purposes. Sometimes scanned printed or photocopied document is produced in office or before court for acceptance. Here the person may claim that original copy of the document was either lost, damaged or not available due to some reasons. In such situations signature becomes disputed. Now comparison of admitted signatures with this copied document becomes necessary. In this situation a question normally raises in mind of a document examiner that whether the printed or photocopied signature shows sufficient signature characteristics for examination and comparison with admitted or not. Researchers have different approaches in the examination of photocopies and printed documents. Earlier researchers have examined photocopied signatures for their identification considering commonly used characteristics height, slant, initial strokes, terminal strokes, pen lifts, pen pause, tremor, hesitation mark. The proposed work extends to find determinant characteristics of signature including some more characteristics that are signature

width, edges of strokes, curvature of strokes, angularity of strokes in scanned and printed as well as in photocopied documents.

4. OBJECTIVE

Main objectives of the study are-

1. To analyze determinant signature characteristics in scan and printed and in photocopied documents incorporating new characteristics.
2. To analyze the effect of different generations of photocopying on decipherment of signature characteristics.

5. MATERIAL & METHOD

Study Design

The Sample:

In total 100 original signatures (i.e. 10 samples from each of the five skilled and five unskilled writers) will be collected. Firstly, these signatures will be scanned and printed using inkjet and laser printers of different company brands and models separately. Secondly, sample signatures will be photocopied from different company brands and models.

All copied documents will be again photocopied for getting the reproduced documents of second generation. This process will be continued to get five generations of photocopied documents.

Tools for Examination:

The present study will be carried out using different physical and spectral methods of analysis. Examination of determinant signature characteristics in scanned printed and photocopied documents as well as decipherment of these characteristics in successive generations of photocopies will be carried out using video spectral comparator.

Tools for Data Analysis:

Data analysis will be carried out using SPSS statistical analytic tool as per standard method.

6. EXPECTED OUTCOME

A Signature may be challenged for its authenticity in any circumstances. A questioned signature submitted to expert for examination may be in any form original, photocopied or scanned printed. There has always been confusion on suitability of scanned printed or photocopied signatures for forensic comparison. The expected outcome of first objective will be helpful in examination of signatures in both the situations scanned printed and in photocopies to ascertain genuineness or otherwise. Identification of determinant signature characteristics in scanned printed and in photocopied documents will contribute in decisive opinion formation in this regard. This study will also be helpful to detect signature forgeries and thereby to ascertain whether the document signed is genuine or fake. Understanding decipherment levels of signature characteristics in different generations of photocopied documents under second objective will be helpful in selection of best available evidence amongst reproduced documents of different generations. It will also help to know probability of finding particular signature characteristic in successive generations of photocopies and will be very helpful in forensic document examination.

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